Volume 9 Issue 1 (2025) Pages 413-422
**Jurnal Obsesi : Jurnal Pendidikan Anak Usia Dini**
ISSN: 2549-8959 (Online) 2356-1327 (Print)

# Enhancing Children's Critical Thinking Through Blended Problem-Based Learning and Eco-Literacy

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DOI: 10.31004/obsesi.v9i1.6885

## Abstract

This study aims to determine the influence of blended problem-based learning and eco-literacy on critical thinking skills in children. This type of research is a quantitative research with a meta-analysis approach. The inclusion criteria in the study are 1) the research must be relevant; 2) research comes from national or international journals indexed by SINTA and Scopus; 3) The research was published in the 2022-2025 time frame; 4) the research must be an experimental or quasi-experimental research; and 5) research obtained from the Google Scholar database; Mendeley, IEEE and ERIC. Data analysis with the JAMOVI application. The results of the study concluded that the 22 effect sizes analyzed had a significant influence of the blended problem-based learning and eco-literacy models on critical thinking skills in children with a value ( $d = 0.991$; $z = 9, 343$ ; $p < 0.001$) in the high effect size category.

**Keywords:** *Model Blended Problem Based Learning; Meta-analysis; Eco-Literacy*



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Received 20 December 2024, Accepted 25 February 2025, Published 28 February 2025

## Introduction

In the era of globalization and the industrial revolution 4.0, critical thinking skills are one of the essential competencies that must be possessed by children (Nadiroh et al., 2019; Ula et al., 2025; Minsih et al., 2024). Critical thinking is not only the ability to understand and process information, but also involves the process of analyzing, evaluating, and reflecting on various problems faced (Syah et al., 2021; Guerrero & Sjöström, 2024). According to *the Partnership for 21st Century Skills (P21),* critical thinking is included in the category *of 21st-century skills* needed to equip children to face the challenges of an increasingly complex world (Sunassee et al., 2021; Mursid et al., 2022). These skills enable children to sort out credible information, recognize biases, and build logical, evidence-based arguments. In the midst of the rapid flow of digital information, critical thinking is the main tool in countering misinformation and hoaxes that can affect individual and societal decision-making at large (Amin et al., 2020; Pursitasari et al., 2022).

Critical thinking skills have an important role in improving the analysis, evaluation, and problem-solving skills in children (Ernawati & Sari, 2022). This ability allows students to explore various points of view, build data-driven solutions, and develop the right strategies

DOI: 10.31004/obsesi.v9i1.6885
in dealing with real problems. A study conducted by Ennis (2018) shows that learners who have good critical thinking skills tend to be more able to overcome academic, social, and environmental challenges more effectively than those who do not have these skills (Suryawan et al., 2023; Nurrijal et al., 2023). Therefore, the development of critical thinking in education must be a top priority, both through innovative learning methods and integration with aspects of daily life (Luciana et al., 2024; Ali et al., 2024; Dewanto et al., 2023); Wantu et al., 2024). Thus, students not only become academically competent individuals, but also have reflective and solutive thinking power in facing future global challenges.

Critical thinking skills are essential skills that must be possessed by students in facing complex challenges in the 21st century(Asnur et al., 2024; Zulkifli et al., 2022). However, the reality on the ground shows that many children still have difficulties in analyzing information in depth, evaluating a problem objectively, and developing evidence-based solutions (Abas et al., 2023). One of the factors that affects low critical thinking skills is that learning methods are still conventional and do not involve students in the process of exploration and real problem solving. In addition, low critical thinking skills are a teacher-centered learning approach and do not provide space for children to explore and solve problems independently(Muhfahroyin et al., 2023; Gök & Boncukçu, 2023). In fact, critical thinking is needed so that children are able to face global challenges, including in making the right decisions related to social, economic, and environmental issues. On the other hand, low awareness and environmental concern in children is also a problem that requires serious attention (Fathonah et al., 2023). Children tend to have limitations in understanding the long-term impacts of human activities on the environment, such as climate change, pollution, and the exploitation of natural resources. The lack of integration of environmental education in the school curriculum makes children less involved in discussions and critical reflection on sustainability issues (Fajri et al., 2023; Wulandari et al., 2024). Therefore, it is necessary to have a learning model that can encourage children's thinking skills in learning namely through blended problem based learning. Blended Problem-Based Learning, which combines problem-based learning with online and offline approaches to optimize learning effectiveness (Burroughs & Bellino, 2024). Blended PBL allows learners to explore issues in more depth with access to digital resources, while still receiving direct guidance from educators. Although previous research has shown that PBL can improve critical thinking skills (Nihlah et al., 2024; Zahran, 2024; Guo et al., 2024).

Eco-Literacy is the ability to understand the basic principles of ecology and the relationship between humans and their environment holistically. In the context of basic education, Eco-Literacy is a crucial aspect in building environmental awareness from an early age, forming a reflective mindset (Manurung & Pappachan, 2025), and encouraging students to be responsible for ecosystem sustainability. Eco-Literacy-based education not only focuses on conceptual understanding of ecology, but also involves critical thinking skills in analyzing environmental problems and finding sustainable solutions (Suryawan et al., 2023; Ernawati & Sari, 2022). Studies show that children equipped with Eco-Literacy tend to be more aware of the impact of human activities on the environment and are more active in taking actions that support sustainability. In addition, the integration of environment-based approaches in learning can improve students' problem-solving and critical analysis skills, as they are trained to evaluate various perspectives, identify patterns of relationships in ecological systems, and formulate solutions based on data and scientific evidence (Okur-Berberoğlu, 2021); (Shevock, 2023). Thus, the application of Eco-Literacy in basic education not only forms a generation that cares about the environment, but also strengthens the critical thinking competencies that are essential in facing global challenges (Manurung & Pappachan, 2025; Wang & Raman, 2025; Ichsan et al., 2023).

Research by Hmelo-Silver (2004) shows that PBL encourages students to be active in solving problems, developing deep understanding, and improving analytical and evaluative skills. In addition, research conducted by Sungur and Tekkaya (2006) revealed that the PBL approach contributes to the improvement of critical thinking skills through the process of

DOI: 10.31004/obsesi.v9i1.6885

exploration, discussion, and reflection. Research by Bernard et al. (2014) shows that Blended Learning, which combines face-to-face and online learning, is able to improve learning effectiveness by providing flexible access to materials and allowing for more dynamic interaction between students and educators. Leh McBride et al. (2013) revealed that ecology-based education can improve analytical thinking skills through understanding the relationships between ecosystems as well as the consequences of human actions on the environment. Furthermore, research conducted by Cebrián and Junyent (2015) highlights the importance of an interdisciplinary approach in developing critical thinking skills through the integration of environmental education in the curriculum. However, until now, there are still limited studies that specifically examine the impact of the combination of Blended PBL and Eco-Literacy on children's critical thinking skills, so further research is needed through meta-analysis to obtain a more comprehensive understanding. Not only that,, Although Problem-Based Learning (PBL) and Blended Learning have been widely studied in the context of improving children's critical thinking skills, there is still a gap in research that explores the effectiveness of the combination of the two in improving the quality of learning. Most existing studies focus on only one approach without considering the synergy between problem-based learning and blended learning that integrates technology (Kerçİn, 2022). In addition, research on Eco-Literacy in primary education generally focuses more on increasing environmental awareness without specifically measuring how ecological literacy can strengthen children's critical thinking skills (Minsih et al., 2024; Guerrero & Sjöström, 2024). The lack of empirical studies that link Blended Problem-Based Learning with Eco-Literacy in the development of critical thinking skills indicates the need for further exploration of the effectiveness of this approach in the context of learning in the digital and sustainable era.

In response to the research gap, this study offers a meta-analysis that combines Blended PBL and Eco-Literacy to build children's critical thinking skills more comprehensively. This approach not only provides space for learners to engage in environment-based problem-solving, but also leverages technology in enriching their learning experience. With the integration of Blended PBL, children can access a wider and more flexible learning resource, while Eco-Literacy helps them in understanding the systemic relationship between humans and the environment and developing sustainability-based solutions. Based on this, this study aims to determine the influence of blended problem-based learning and eco-literacy on critical thinking skills in children.

## Methodology

This study uses a meta-analysis approach to determine  the influence of blended problem-based learning and eco-literacy on critical thinking skills in children. Meta-analysis is a research approach that evaluates previous research statistically to reach a conclusion (Tamur et al., 2020; Badawi et al., 2023; Nurtamam et al., 2023; Zulyusri et al., 2023;  Bachtiar et al., 2023). The meta-analysis research procedure is 1) determining the research inclusion criteria, 2) collecting data and coding, 3) analyzing the data statistically.
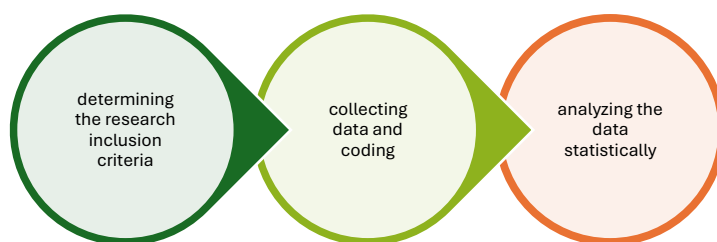
**Figure 1. Meta-analysis Research Procedure**

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### *Eligibility Criteria*

In the process of searching for data through the Google Scholar, ScienceDirect, Wiley, ERIC, ProQuest, Fronteins and Web of Science databases, the research must meet several inclusion criteria, namely are 1) the research must be relevant; 2) research comes from national or international journals indexed by SINTA and Scopus; 3) The research was published in the 2022-2025 time frame; 4) the research must be an experimental or quasi-experimental research; and 5) research obtained from the Google Scholar database; Mendeley, IEEE and ERIC. From the data search, 22 studies were obtained that met the inclusion criteria published in 2022-2025 which can be seen in Table 2.

### *Statistical Analysis*

Data analysis in this study calculates the effect size value of each study analyzed. The effect size value in this study is to calculate the effect of the influence of blended problem-based learning and eco-literacy on critical thinking skills in children. Furthermore, the criteria for the effect size value in the study can be seen in Table 1.

**Table 1. Category Effect Size Value**

| Effect Size | Category |
|---|---|
| **0.0≤ES≤ 0.2** | Low |
| **0.2≤ES≤ 0.8** | Medium |
| **ES≥ 0.8** | High |

Source: (Borenstein et al., 2007; Bachtiar et al., 2023; Tamur et al., 2020; Tamur et al., 2021; Nurtamam et al., 2023)

## Result and Discussion

Based on the results of data search through the database, 22 studies/articles met the inclusion criteria. The effect size and error standard can be seen in Table 2.

**Table 2. Effect Size and Standard Error Every Research**

| Code Journal | Years | Effect Size | Standard Error | Database |
|---|---|---|---|---|
| **AT 1** | 2025 | 1.03 | 0.45 | Google Scholar |
| **AT 2** | 2023 | 0.93 | 0.30 | ERIC |
| **AT 3** | 2023 | 0.77 | 0.19 | ERIC |
| **AT 4** | 2025 | 2.09 | 0.30 | ERIC |
| **AT 5** | 2024 | 1.18 | 0.40 | Google Scholar |
| **AT 6** | 2024 | 0.52 | 0.19 | IEEE |
| **AT 7** | 2024 | 0.28 | 0.29 | IEEE |
| **AT 8** | 2024 | 1.19 | 0.37 | IEEE |
| **AT 9** | 2025 | 1.89 | 0.33 | ERIC |
| **AT 10** | 2022 | 0.83 | 0.32 | Wiley |
| **AT 11** | 2022 | 0.62 | 0.29 | Google Scholar |
| **AT 12** | 2025 | 0.98 | 0.55 | Google Scholar |
| **AT 13** | 2022 | 0.71 | 0.23 | ERIC |
| **AT 14** | 2025 | 0.44 | 0.25 | ERIC |
| **AT 15** | 2024 | 1.07 | 0.27 | ERIC |
| **AT 16** | 2024 | 0.86 | 0.33 | ERIC |
| **AT 17** | 2023 | 1.92 | 0.31 | Mendeley |
| **AT 18** | 2022 | 1.28 | 0.37 | Mendeley |
| **AT 19** | 2023 | 1.02 | 0.40 | Google Scholar |
| **AT 20** | 2023 | 0.74 | 0.25 | ERIC |
| **AT 21** | 2022 | 0.64 | 0.20 | ERIC |
| **AT22** | 2025 | 1.47 | 0.30 | ERIC |

Based on Table 2, the effect size value of the 24 studies ranged from 0.49 to 2.91. According to Borenstein et al., (2007) Of the 24 effect sizes, 6 studies (25%) had medium criteria effect sizes and 18 studies (75%) had high criteria effect size values. Furthermore, 24 studies were analyzed to determine an estimation model to calculate the mean effect size. The analysis of the fixed and random effect model estimation models can be seen in Table 3.

**Table 3. Fixed and Random effect**

| | Q | df | p |
|---|---|---|---|
| **Omnibus test of Coefficients Model** | 312.276 | 1 | < 0.001 |
| **Test of Residual Heterogeneity** | 83.461 | 22 | < 0.001 |

Based on Table 3, a Q value of 312.267 was obtained higher than the value of 83.461 with a coefficient interval of 95% and a p value of 0.001 <. The findings can be concluded that the value of 22 effect sizes analyzed is heterogeneously distributed. Therefore, the model used to calculate the mean effect size is a random effect model. Furthermore, checking publication bias through funnel plot analysis and Rosenthal fail safe N (FSN) test (Tamur et al., 2020; Badawi et al., 2022; Ichsan et al., 2023b; Borenstein et al., 2007; Ulum, 2022). The results of checking publication bias with funnel plot can be seen in Figure 2.
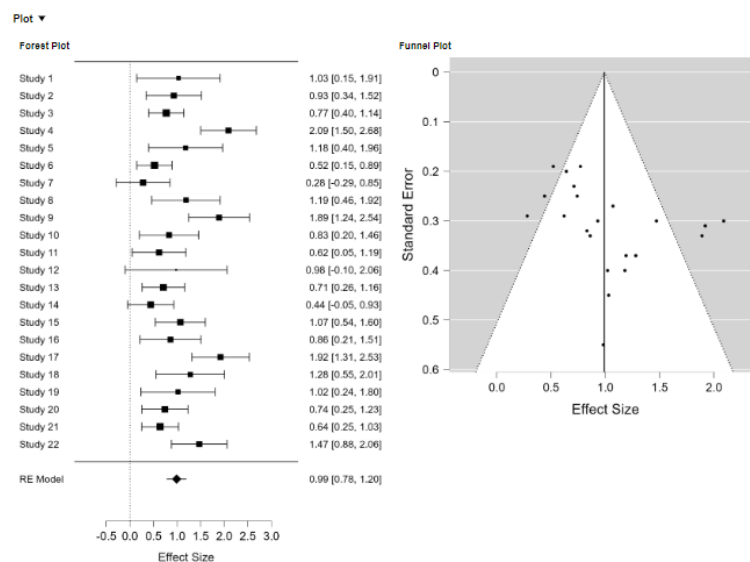
**Figure 2. Forest and Funnel Plot**

Based on Figure 2, the analysis of the funnel plot is not yet known whether it is symmetrical or asymmetrical, so it is necessary to conduct a Rosenthal Fail Safe N (FSN) test. The results of the Rosenthal Fail Safe N calculation can be seen in Table 4.

**Tabel 4. Fail Safe N**

| **File Drawer Analysis** | | | |
|---|---|---|---|
| | Fail Safe N | Target Significance | Observed Significance |
| **Rosenthal** | 1959 | 0.050 | < 0.001 |

Based on Table 4, the Fail Safe N value of 1959 is greater than the value of 5k + 10 = 5(22) + 10 = 120, so it can be concluded that the analysis of 22 effect sizes in this data is not biased by publication and can be scientifically accounted for. Next, calculate the p-value to test

DOI: 10.31004/obsesi.v9i1.6885

the hypothesis through the random effect model. The results of the summary effect model analysis with the random effect model can be seen in Table 5.

**Tabel 5. Summary/ Mean Effect Size**

| **Coefficient** | | | | | | |
|---|---|---|---|---|---|---|
| | Effect Size | Standard Error | z | p | 95% Coefficient Interval | |
| | | | | | Lower | Upper |
| **Intercept** | 0.991 | 0.106 | 9.343 | < 0.01 | 0.783 | 1.981 |

Table 5, the results of the mean effect size analysis are 0.991 with a standard error of 0.106. These findings explain that there is a positive influence of the blended problem-based learning and eco-literacy model on critical thinking skills in children compared to the conventional model with a high value ($z = 9.343$ ; $p < 0.001$) in the effect size category. Problem-Based Learning (PBL) has been recognized as an effective pedagogical approach in improving critical thinking skills because it requires learners to identify, analyze, and solve problems independently. However, challenges in conventional PBL implementation, such as limited face-to-face time and access to diverse learning resources, have raised the need for a more flexible approach(Kerçİn, 1992). Therefore, Blended PBL, which combines problem-based learning with digital technology, is considered an innovative solution that is able to optimize the learning process by providing wider access to learning resources, enabling more dynamic interactions, and increasing learning effectiveness (Latif et al., 2023; Guerrero & Sjöström, 2024).

In addition to the problem-based pedagogical approach, environmentally-oriented education such as Eco-Literacy also plays an important role in building children's critical thinking skills. Eco-Literacy refers to understanding the relationship between humans and ecosystems and the impact of human activities on the environmen(Mursid et al., 2022)t. Through this approach, students are invited to think systematically and develop ecological awareness in daily life. In the context of education, the integration of Eco-Literacy in the curriculum can encourage students to hone their skills in analysis, evaluation, and problem-solving based on environmental issues (Sukri & Lukitasari, 2022). Previous studies have shown that when children engage in environment-based learning, they not only increase their ecological awareness, but also have better critical thinking skills in evaluating and finding solutions to environmental problems around them (Muhfahroyin et al., 2023; Nihlah et al., 2024).

Blended PBL and Eco-Literacy in learning provide a more comprehensive interdisciplinary approach in improving children's critical thinking skills(Shevock, 2023). Blended PBL provides flexibility in learning by utilizing digital technology for problem exploration, online discussions, and access to a wider range of resources. Meanwhile, Eco-Literacy instills a contextual understanding of environmental issues, which requires students to think systemically and solutionally (Zahran, 2024). By combining these two approaches, children not only learn to solve problems of an academic nature but also develop a critical understanding of real environmental challenges. This approach also strengthens reflective thinking and evidence-based decision-making skills, which are crucial in building a more sustainability-conscious generation (Tiwari, 2023); LIacono et al., 2024).

## Conclusion

From the results of this study, it can be concluded that the 22 effect sizes analyzed have a significant influence of the blended problem-based learning and eco-literacy models on critical thinking skills in children with high value ( $d = 0.991$ ; $z = 9.343$; $p < 0.001$) category. The combination of these two approaches creates a learning environment that is more interactive, contextual, and relevant to real-world challenges. Thus, this study corroborates

DOI: 10.31004/obsesi.v9i1.6885

that an interdisciplinary approach that combines innovative learning methods and environment-based education can be an effective strategy in improving 21st century competencies, especially critical thinking skills. Recommendations for educators, policymakers, and education researchers to further adopt the Blended PBL and Eco-Literacy models in the primary school curriculum. Educators need to design learning activities that integrate technology with environmental problems directly so that children can develop critical thinking skills holistically. In addition, policymakers in the education sector can consider implementing policies that support the implementation of problem-based learning with sustainability content. Further research can explore other factors that influence the effectiveness of this approach, such as differences in learners' ages, cultural contexts, and the availability of learning resources. With a more comprehensive and evidence-based approach, education systems can be more adaptive in preparing young people to face increasingly complex global challenges.

## Acknowledgments

The author would like to thank the researchers who have collaborated in completing this study.

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